Terrestrial Vertebrate Monitoring
Channel Islands National Park
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ABSTRACT

Terrestrial vertebrate monitoring was begun at Channel Islands National Park during the spring of 1993. Previously developed monitoring protocols for island fox, island deer mice, pacific slender salamanders, and several species of lizard were implemented on San Miguel, Anacapa, and Santa Barbara islands. Estimates of population size and density are presented for two island fox grids and five deer mouse sampling grids. Results are presented for seven amphibian/reptile sampling transects, although data obtained were insufficient for population or density analysis. This being the first year of monitoring there was very little information from previous sampling available for comparison. Where past data exists or relevant studies have been completed, such information is compared with our data.

Much time was spent this first year on transforming what was proposed in the written protocol into what would actually work in the field. Mostly as a result of trial and error, we have made changes to the protocol where needed. These are mainly changes in timing or location of sampling, generally not in sampling procedure. The nature of these modifications and grounds for their implementation are discussed.

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INTRODUCTION

This report describes and reviews the first year of terrestrial vertebrate monitoring at Channel Islands National Park. The monitoring protocol for terrestrial vertebrates was designed by Fellers, Drost, and Arnold in 1988 and published for the park as the Terrestrial Vertebrate Monitoring Handbook, hereafter referred to as the handbook. We initiated all our sampling procedures based on these guidelines, making alterations to the protocols when necessary. During this first year seven species on three islands were sampled for population size and density. Additional measurements relating to sex ratio, recruitment characteristics, demographics, and physical attributes were taken for some species.

This report presents the dates, locations, and results of all sampling, along with explanations of what deviations were made from the handbook instructions and why we felt such changes were needed. The table below presents the species that are monitored in the terrestrial vertebrate program, the islands where each species exists, the schedule of sampling as listed in the monitoring handbook, and the dates of actual sampling (Table 1).

Sampling is conducted on Anacapa, Santa Barbara, and San Miguel islands (Figures 1 through 4). The sampling schedule as designed was intended to adequately sample all terrestrial vertebrate species on all islands during all seasons relevant to the natural history of each species. Biological and logistical realities dictated that we modify this schedule. While we required a schedule which would provide valuable data, we also needed a schedule we could realistically adhere to, both this year and in future years. Each section below describes the methods of sampling, the changes made to the scheduel published in the handbook, and whether the changes were based

Table 1. List of all monitored species, islands where they occur, and scheduled and actual sampling periods.

SPECIES	Santa Barbara Island (SBI)	Anacapa Island (AI)	San Miguel Island (SMI)	Scheduled sampling dates	Actual sampling dates
Island fence lizard *(Sceloporous occidentalis becki)*			X	Dec/Jan/Apr	Mar/Apr
Side-blotched lizard *(Uta stansburiana)*		X		Dec/Jan/Apr	Mar/Apr
California alligator lizard *(Elgaria multicarinata multicarinata*)		X	X	Dec/Jan/Apr	Mar/Apr SMI - Dec/Jan
Island night lizard *(Xantusia riversiana)*	X			Dec/Jan/Apr	Mar/Apr/Oct
Pacific slender salamander (*Batrachoseps pacificus pacificus)*		X	X	Dec/Jan/Apr	Mar/Apr SMI - Dec/Jan
Deer mouse *(Peromyscus maniculatus subsp.)*	X	X	X	SBI & AI - Mar/Aug SMI - Apr/Sept	SBI - Mar/July/Oct. AI & SMI - Apr
Island fox *(Urocyon littoralis)*			X	Feb/Mar/Apr.	August

Figure 1. Deer mouse sampling grids and amphibian/reptile sampling transects on Anacapa Island.

Figure 2. Deer mouse sampling grids and night lizard sampling transects on Santa Barbara Island.

Figure 3. Deer mouse sampling grids and amphibian/reptile sampling transects on San Miguel Island.

Figure 4. Island fox sampling grids on San Miguel Island

on logistical considerations or ecological factors.

Since this was the first year of sampling, there is very little previous data with which to compare our results. Intensive studies were conducted on two of the species, the island deer mouse (*Peromyscus maniculatus elusus*), on Santa Barbara Island, and the island night lizard (*Xantusia riversiana*) on Santa Barbara Island, during the 1980's. Population trends and densities recorded in these studies will be briefly compared with what we found in 1993 for these populations. However, for the most part, our data are presented without analysis. The goal of the terrestrial vertebrate monitoring program is to detect significant changes in population numbers over time either between sites on one island or between different islands. Since there are very few earlier data which we have access to, there is no way to know whether this years's data for any particular species represent some unknown, ongoing change, or define the situation of stable populations. Between-site differences will be discussed if they seem to reflect habitat variety. Otherwise, between-site comparisons will be deferred to future years.

AMPHIBIANS AND REPTILES

INTRODUCTION

Four lizard and one salamander species occur on the three monitored islands (Table 1). Of these, the island night lizard, *Xantusia riversiana,* is a Federally listed threatened species, and the pacific slender salamander, *Batrachoseps pacificus,* is a candidate species for Federal listing. The island night lizard was the subject of an intense ecological study during the 1980's, (Fellers and Drost 1991), however the other species have not been well studied.

Presented below is a brief description of each monitored species, followed by a description of the sampling method and results from this year. Included in the results are observations of the natural history of each species and how they may relate to the timing of sampling periods. In some cases our increased knowledge of such factors as the age of the young during proposed sampling periods, breeding times, and behavioral responses to seasonal weather changes has persuaded us to modify the schedule for future years.

SPECIES DESCRIPTIONS

The physical characteristics and life history information presented below for amphibians and reptiles is from Stebbins (1966) unless otherwise noted.

Island fence lizard (*Sceloporous occidentalis becki)* - San Miguel Island

Side-blotched lizard *(Uta stansburiana)* - Anacapa Island

(Because of their behavioral and ecological similarities these two lizards are described together).

Island fence lizards are relatively small lizards (57 - 90 mm snout-vent length [SVL]), with this subspecies being found only on the California Channel Islands. *S. o. becki* is distinguished from other fence lizard subspecies by slight color variations on the throat. These lizards feed on insects and other invertebrates, and lay their eggs in late spring and early summer. Side-blotched lizards are smaller, (38 - 60 mm SVL), and are identified by lateral black spots behind the front limbs. This species is found throughout the western U.S. and has not evolved into an island subspecies. These lizards have a longer period of egg-laying (Mar.-Aug) and feed on a greater variety of invertebrates than do the fence lizards.

These two species are quite similar in their behavior. Both are often observed in the open on rocks, trails, and near structures during sunny times of the day. As stated in the monitoring handbook, though, neither of these species is usually observed under cover boards. The high frequency with which they are observed in the open may allow us in the future to establish a protocol where we count the average number of animals seen along a trail during one trip or some other repeatable method, but current monitoring methods do not allow for adequate sampling of fence lizards or side-blotched lizards.

California alligator lizard (*Elgaria multicarinata multicarinata)* - San Miguel and Anacapa islands

Alligator lizards are larger than either side-blotched lizards or fence lizards (73 - 178 mm SVL) and seem to be more aggressive. They feed on a greater variety of invertebrates than the other lizards and may even eat other lizards and small mammals. This lizard will lay 1-3 clutches, each of 5-20 eggs, between May and July.

Alligator lizards generally frequent moist environments in foothills and mountains, but are also found near springs and streams in more arid environments. They are more secretive than the other lizards on the islands, and they seek out the protection and moisture offered by the cover boards.

Island night lizard *(Xantusia riversiana)* - Santa Barbara Island

The island night lizard is a medium-sized lizard (70-100 mm SVL). They are endemic to the Channel Islands, occurring on Santa Barbara, San Nicolas, and San Clemente islands. These lizards prefer habitats of very dense vegetation, such as thick clumps of boxthorn, *Lycium californicum*, and prickly pear cactus, *Opuntia littoralis* and *O. oricola* (Fellers and Drost, 1991). Mating occurs in the spring, and young island night lizards are born in September and remain active throughout the winter (Fellers and Drost, 1991). Adults are much more active during the spring mating season, and activity for these animals falls off dramatically in the fall and winter (Fellers and Drost, 1991). Night lizards on Santa Barbara were found to be quite longed-lived, with the oldest being recorded at over 12 years of age (Fellers and Drost, 1991). Night lizards feed mostly on invertebrates and plant materials, but exhibit a large amount of seasonal variation in their food habits (Fellers and Drost, 1991).

Pacific slender salamander (*Batrachoseps pacificus pacificus)* - Anacapa and San Miguel islands

The Channel Islands slender salamander is large with respect to the other slender salamanders, but is very similar to them in appearance. Slender salamanders in general are relatively long with short limbs, and have costal and caudal grooves which give them a worm-like appearance.

Very little seems to be known about the biology of this subspecies. They occur in damp places, under logs and leaf litter and the like, and consequently are often found under our transect cover boards. They do not have the ability to dig their own burrows, but use excavations of other animals and cracks in the soil, in addition to man made tunnels and crevices (Bishop 1943). Because of this they must descend from the surface to moist areas underground before the late spring. Eggs are laid while the female is below ground, and the adults and the young animals migrate to the surface during the early rains in the fall and winter. The timing of this cycle is highly dependent on weather, and varies greatly between wet and dry years (Stebbins 1951).

METHODS

The amphibian and reptile monitoring program provides two measures of population status: an uncalibrated index of population size and a weight-length regression, used for comparing weights of various age classes between years (Fellers, et al. 1988). To do this, amphibians and reptiles are sampled using cover boards as artificial habitat. Most of these boards are 12" x 12" x 2" pieces of pine or fir, and are placed in transect lines in various habitats on the islands. (During the initial design studies for the program, plywood and 4" thick pine boards were also tested, and in some cases these boards remain on the transects. By the end of next year, all of those boards will be replaced with the 2" pine or fir boards selected for the program). These transects have been in place for many years, and the animals are accustomed to the boards and utilize them for protective cover. When the board is turned over, any animals present are caught, measured, marked if necessary, and released. (In addition to counts and measurements of alligator lizards, on West Anacapa Island we marked alligator lizards with toe clipping for future age studies.) The detailed methodology is described in the monitoring handbook. In some habitats, large cracks form under the boards over time, creating spaces where animals can quickly run when disturbed and avoid capture by researchers. In these cases we have moved the entire row of boards a foot or so to one side. Additional observations of amphibians and reptiles will be obtained with the initiation of the invertebrate monitoring program next year, as invertebrate sampling involves many of the same cover boards as are used in the vertebrate sampling. All reptiles and amphibians observed during invertebrate monitoring will be noted, although measurements will not be taken.

Sampling activity was maintained as close as possible to the protocol schedule, except in the case of the island night lizard which will be discussed below. Observations this year have provided an indication of the above-ground activity periods for each species. However, for several reasons, the 1993 data are insufficient to present either a population size index or a weight-length regression.

The absence of a population index is due to the lack of adequate sampling occasions. To calculate an index of population size, the protocol directs that each transect of boards be checked three times per year, and for all species but the night lizard, two of these sampling periods must be during winter months. The decision was made to include the 1993-1994 winter season as the beginning of the 1994 sampling period, since changes in recruitment, growth, and population numbers seen in the spring and fall are mostly dependent on rainfall effects from the previous season. Consequently, the sampling year from now on will begin with the winter. Our program did not begin until March of last year so the 1992-1993 winter season was not included in the sampling.

A second factor affecting the amount of data collected this year was the poor condition of the sampling boards. All of the boards were placed during the development phase of the monitoring program five or six years ago, and were not maintained from that time until this year. When the transects were first checked this spring, many of the boards were found to be cracked or broken, or as was the case on East Anacapa Island, not present at all. Since they were apparently unused, some of the cover boards were removed by island personnel, but we were unaware of this until we went to check them. Also, on this island both of the transects were located in Western Gull (*Larus occidentalis)* nesting habitat. Since the gulls begin nesting in the spring and that was when we first realized we would have to replace most of the boards, by the time we purchased the boards and made arrangements to take them to the island, gull chicks were present. Consequently we had to wait until the chicks were fledged in the fall to replace the boards. Because these boards need to be in place for several months before they are reliable as cover, we were unable to obtain data from these transects this year.

Cumulatively, a significant amount of time was spent this year on maintenance and replacement of the boards on all the islands. In future years only small number of individual boards should need to be replaced.

Data was not obtained from four other transects, one on Middle Anacapa, one on San Miguel, and two night lizard transects on Santa Barbara. On Middle Anacapa one of the transects could not be located. The location of the Sagebrush transect, as mapped in the handbook, is described only as being only in sagebrush, and to the east of the Grassland transect. The vegetation in this area is quite thick, and has likely grown up quite a bit since the boards were placed. There are no stakes or landmarks, and although we went out twice, we simply could not find this location. Because of the difficulties of getting to Middle Anacapa, it was not possible to make another trip to lay out more boards. We will likely do so during the spring of 1994 during the scheduled sampling trip. Also, for unknown reasons, both of the transects on Middle Anacapa consist of only 30 boards, as opposed to 60 boards on all the other transects. We may enlarge these transects to 60 boards next year.

On San Miguel, the Green Mountain transect was not sampled, simply because of lack of time. Green Mountain is quite a distance from the other transects, and we spent considerable time this year locating the transects closer to the station, as they were very grown over by grass and iceplant. Next year we intend to sample the Green Mountain transect along with the others.

The Webster Point transect on Santa Barbara was not accessible during the spring sampling period due to western gull nesting, and was not sampled this year. The Middle Canyon transect is located in very thick vegetation, and was not located until late in the season. We will attempt to sample this transect for night lizards next year.

Weight-length regressions are not presented for any reptile or amphibian species for this first year. We accepted at the outset that our animal handling and measurement techniques would develop over the season, but were not adequate enough during the initial sampling periods to make us confident in the results. Long term trends of weight-length regressions will appear from differences of only a few millimeters, and we felt that our measurements this year could in some cases have been in error by such an amount. It is likely that by the later sampling periods our measurements were accurate, but it is impossible to know from just what point our skills were improved enough that the data can be considered reliable.

The protocol for sampling of island night lizards was changed significantly during this first year (Table 1, Appendix A). An exhaustive study of island night lizard ecology was conducted on Santa Barbara Island from 1981-1989 (Fellers and Drost 1991). This study concluded that island night lizard populations on Santa Barbara Island are large in number and probably increasing, demonstrating recovery ability following habitat disturbances earlier this century. In addition, the species was found to be quite long-lived, and existing in higher densities than had previously been known for any other ground-dwelling species of lizard. These researchers had also written the night lizard monitoring protocol, which prior to their study had called for three sampling sessions on each of five transects every year. However, based on the results of their research, the authors communicated to the park that, while they felt that it was certainly important to continue to monitor this population, the intensity of sampling as described in the protocol was probably not necessary (Fellers and Drost, personal communication, May 1993). Based on this information, and the desire to disturb the animals as little as possible, we decided to modify the protocol, and sample this species less often.

Fellers and Drost's study results also shows that sampling during the fall season allows for greater observations of young lizards, which are much less active in the spring and summer. The sampling schedule as written did not call for sampling in the fall. Cumulatively, these comments led us to postpone sampling until the summer, when we would be conducting deer mouse sampling, and to add one sampling period in the fall. In the future we will reduce our sampling to one spring and one fall period on only two or three of the established transects. After a few more years of observation, we may schedule a complete sampling of every transect every five years, or some other appropriate schedule.

During our summer night lizard sampling, in addition to measuring the animals, we also marked individuals on one transect by means of toe clipping. The methods used were identical to those used by Fellers and Drost (1991) during their study, and in fact we continued with their numbering system. Marking the animals is not presented in the handbook as part of the monitoring program. The maximum potential age of night lizards is unknown, however, and we felt that we had in this situation a good opportunity to continue a long-term demographic study of a previously-marked population within the guidelines of the monitoring program. We are planning to continue marking animals on one transect per year.

RESULTS

Fence lizard and side-blotched lizard

For 1993 there is very little data for these species. Both were often observed incidentally on their respective islands, but only two fence lizards were ever observed under cover boards on San Miguel Island.

Alligator lizard

Because of this year's limited data, there is no observable pattern of the seasonal habits of alligator lizards. Table 2 gives the number seen at each location throughout the year. Sampling on West and Middle Anacapa is difficult for several reasons. Access to the islands is by means of skiff landings, which are only possible during the best of sea conditions. Also, both of these islets are closed to access during the brown pelican (*Pelecanus occidentalis*) nesting season, which runs from approximately March to August but can be as long as December to September. While our sampling sites are not near pelican rookery areas, we restrict our visits to the island to the non-breeding season, which restricts our sampling to one period only. And as was discussed above, on East Anacapa the cover boards were removed from the island prior to our sampling, and this year of data was missed because the boards had to be replaced. Consequently, data from Anacapa is limited.

Alligator lizards were not seen on San Miguel during the spring sampling. Further sampling in the winter will likely show that these animals spend much more time under the boards (near the surface) during the wetter times of the year, while during the hotter, drier months they migrate deeper into the soil or travel to some unknown location.

Island night lizard

Night lizards were common on the transects which were sampled in the summer, and were abundant in October (Table 3a). Due to the high number of lizards observed, during the fall sampling we did not handle the animals, but only estimated the lengths, and divided observed animals into small (approximately 60-80 mm total length), medium (80-140 mm), and large (>140mm) size classes. While not part of the protocol, we may in the future be interested in calculating the relative age of these lizards using the methods developed by Fellers and Drost (1991). As was noted by these authors, we also observed numerous juvenile (smaller) night lizards during the fall sampling period (Table 3b). Also during our fall sampling, we examined a

Table 2. Alligator lizards *(Elgaria multicarinata multicarinata)* observed on transects of 60 cover boards, Anacapa and San Miguel islands, 1993

Island	Date	Transect	# Lizards seen
West Anacapa	3/20/93	Grassland	5
Middle Anacapa*	3/23/93	Grassland	1*
San Miguel	4/8/93	Air strip	0
San Miguel	4/8/93	Nidever Canyon	0
San Miguel	4/9/93	San Miguel Hill	0
San Miguel	4/15/93	Willow Canyon	0

* 30-board transect

lizard which had been marked by Fellers and Drost, and was determined by us to be at least 13 years old. A long-term study on San Nicolas Island has revealed one night lizard that lived at least 18 years (Drost, pers. comm.).

Pacific slender salamander

Salamanders were were only sampled in the spring of this year, and were not common under the boards during those times, except on the Air Strip (AS) transect on San Miguel (Table 4). On that transect they were numerous. The AS transect on San Miguel is in mixed grassland-shrub habitat, while the other two transects Willow Canyon (WC), and Nidever Canyon (NC) are located in grassland and lupine-iceplant habitat respectively. The obvious preference by the salamanders of this habitat over the others may indicate the presence of several habitat variables of high quality (i.e. physical attributes, microhabitat conditions, food sources, etc.). As is the case with all of our results this year, many more observations will be necessary before habitat use patterns become obvious.

An interesting observation of salamanders was made by a member of our marine biology staff in December. While doing marine debris surveys on a beach on San Miguel, approximately 20 salamanders were seen under a buoy that had washed up. This buoy was above the high tide mark, but near the outlet of a stream. The means of travel of the salamanders to this spot is unknown; it is possible they were transported downstream during flood events. It was decided that we will attempt to sample such beach/riparian sites, checking under both natural and artificial habitat, in future seasons. The monitoring protocol does not call for sampling of beach or stream sites. However, the presence of 20 or more animals in one location clearly suggests the

Table 3a. Night lizard *(Xantusia riversiana)* observations on transects of 60 cover boards on Santa Barbara Island, 1993.

Date	**Transect**	**# seen**
7/17/93	Terrace grassland	7
7/20/93	Middle-Graveyard canyons	9
10/14/93	Cave-Middle canyons	38

Table 3b. Number of night lizards *(Xantusia riversiana)* observed in each size class on transects of 60 cover boards on Santa Barbara Island, 1993.

Date/Transect	Small (50-80 mm)	Medium (81-140 mm)	Large (>140 mm)
7/17/93 - Terrace grassland	1 (14%)	3 (43%)	3 (43%)
7/20/93 Middle-Graveyard Cyns	1 (12%)	4 (44%)	4 (44%)
10/14/93 Cave-Middle Cyns	12 (31.5%)	14 (37%)	12 (31.5%)

Table 4. Pacific slender salamander *(Batrachoseps pacificus)* observations on transects of 60 cover boards, Anacapa and San Miguel islands, 1993.

Island	Date	Transect	# Salamanders seen
West Anacapa	3/20/93	Grassland	8
Middle Anacapa	3/23/93	Grassland	2*
San Miguel	4/8/93	Air strip	17
San Miguel	4/8/93	Nidever Canyon	2
San Miguel	4/9/93	San Miguel Hill	0
San Miguel	4/15/93	Willow Canyon	0

* 30-board transect

suitability of these areas, at least during this time of year. Since very little is known about this potentially threatened salamander, a greater effort is going to be made by us next year to locate additional sites for monitoring of this species.

MAMMALS

Deer mice *(Peromyscus maniculatus subsp.)*

INTRODUCTION

Deer mice are present on all the islands except East Anacapa islet, where their absence is likely due to the presence of roof rats *(Rattus rattus)*. Deer mouse monitoring is currently conducted on San Miguel, Santa Barbara, and Middle and West Anacapa islands. A separate subspecies of deer mouse has evolved on each island (Collins et al. 1979) (Table 5). On Santa Barbara and Anacapa islands deer mice are the only native terrestrial mammal, while on San Miguel Island the island fox is also present. The lack of other terrestrial mammals to act as predators and competitors has allowed the deer mouse to exploit nearly every habitat on the islands, (Collins et al. 1979; Drost and Fellers, 1991), and they have done so with great success. Extremely high densities of mice following recruitment periods often result in population crashes during the winter (Drost and Fellers, 1991). Deer mouse densities on Santa Barbara Island have reached levels higher than ever recorded anywhere (Drost and Fellers, 1991), and because they are extremely important as consumers, their impact as seed predators on both native and non-native plant species is of interest. One goal of deer mouse monitoring is to determine the correlations of mouse cycles with fluctuations in rainfall, vegetation, invertebrates, seabirds, and island fox population numbers.

Table 5. Subspecies of *Peromyscus maniculatus* on the California Channel Islands

Island	**Subspecies**
San Miguel	*Peromyscus maniculatus streatori*
Santa Rosa	*P. m. santaerosae*
Santa Cruz	*P. m. santacruzae*
Anacapa	*P. m. anacapae*
Santa Barbara	*P. m. elusus*
San Nicolas	*P. m. exterus*
Santa Catalina	*P. m. catalinae*
San Clemente	*P. m. clementis*

Deer mice also have an impact on island personnel and visitors. Mice often reach very high densities near residences and campgrounds for several months during the summer and fall. The recent discovery of the potentially fatal Hanta virus in deer mice in other areas has increased concern regarding the numbers of deer mice in and around structures and residences.

METHODS

Deer mouse sampling is conducted in various habitats using live trap sampling grids, as described in detail in the monitoring handbook (Fellers et al., 1988). Data analysis for deer mouse (and island fox) populations is performed by the program CAPTURE, a software package commonly used to statistically analyze data obtained in capture/recapture studies (White, et al. 1982). This program determines the most appropriate population estimation model from the data presented. Several of these models include robustness for variable capture probabilities, such as changes in capture success over time resulting from differences in behavior of the individual or changes in weather causing increases or decreases in total animals caught. The program recommends which model to use and then continues with analysis using the selected model unless directed otherwise.

During the latter part of their study, Drost and Fellers (1991) utilized identical methodology as described in the handbook for deer mouse sampling on Santa Barbara Island. To insure that our trap data would be compatable with theirs and allow continuation of analysis into the future, those of us involved in deer mouse monitoring conducted a trapping session in both the Grassland and the

Coreopsis grid on Santa Barbara Island with C. Drost in September, 1992. During this time we discussed both trapping techniques and data analysis procedures.

RESULTS

Deer mouse numbers were very low at all sites sampled in the spring, but were extremely high at the two sites sampled on Santa Barbara Island in the summer and fall (Table 6). This pattern of population decline during the winter followed by dramatic increases caused by recruitment of juveniles is common in short-lived rodent species (Jameson 1955; Briese and Smith 1974; Golley, et al. 1975), and would be expected after the reproductive period in April and May. The number of litters produced by each female is likely dependant on food availability. Deer mice are omnivores (Ingles 1965) and, as island personnel know, will eat almost anything. Reproduction, however, is probably most dependant on the amount of new vegetation growth, which directly correlates with annual precipitation amounts (Meyers and Krebs 1974; Drost and Fellers, 1991). This year on the Grassland grid on Santa Barbara Island there was an increase from mouse densities that were so low as to be unmeasureable, to an estimate of 612/hectare within a period of four months (Table 6). This value is much higher than that ever recorded by Drost and Fellers, (372 +/- 30 maximum recorded on the Grassland grid). Slight variations in data interpretation may have been responsible for some differences in density estimates, however, it would appear that densities during 1993 were even greater than those observed by Drost and Fellers, since results generated through CAPTURE should be comparable.

Table 6. Deer mouse captures and density estimates (total captures includes recaptures of all individuals)

Island	Date	Grid/ Habitat Type	# Individuals Captured	Total # Captures	Estimated density/ha	Estimated population (Confidence interval)
Santa Barbara	3/3-5/93	Terrace *Coreopsis*	22	49	38.2	22 (20-24)
Santa Barbara	3/3-5/93	Terrace grassland	6	9	*	*
West Anacapa	3/20-22/93	Grassland	6	7	*	*
Middle Anacapa	3/23-25/93	Grassland	17	27	4.5**	18 (16-29) (Peterson method)
San Miguel	4/7-9/93	Nidever Canyon (lupine-iceplant)	46	112	98.5	46 (44-48)
San Miguel	4/7-9/93	Air strip (grassland-shrub)	26	48	19.5	28 (24-32)
San Miguel	4/14-16/93	Willow Canyon (grassland)	19	36	26.1	20 (17-23)
Santa Barbara	7/17-19/93	Terrace grassland	144	182	612.3	245 (217-274)
Santa Barbara	10/12-15/93	Terrace *Coreopsis*	208	332	659.1	307 (279-337)

* insufficient captures for estimate
** naive estimate: estimate of N/area of grid

Although we did not run any sampling grids in the winter, we did have traps out on San Miguel during December and January for Hanta virus testing. During 100 trap nights during the December session (70 traps in two grassland areas and 30 traps in a mixed shrub/grassland) only 11 mice were caught. In January, we conducted 300 trap nights, approximately 1/2 near the ranger residence, and 1/4 each in grassland near the campground and along the Air Strip trail, and caught approximately 60 mice. Although densities cannot be calculated from this capture information, obviously mouse numbers were low, and similar to those found during spring sampling.

A comparison of density estimates between similar habitats on different islands presents the initial observation that grassland habitat is less favored by mice than habitat defined by more woody-type vegetation, such as lupine and *Coreopsis*. On Santa Barbara and San Miguel islands where grassland can be compared with these other habitat types, in both cases the grassland sites support fewer mice (Table 6).

Average weights by age class are presented in Figure 5. Weights are highest in the spring when vegetation is abundant and densities are low, and are lowest in the fall when preferable food sources become scarce and densities increase. These data will be of greater interest when combined with rainfall and additional annual observations over many years. Deer mouse monitoring is a crucial element of the terrestrial vertebrate program, since these animals are so abundant at times and are such an important component of the terrestrial community. If Hanta virus is found in any of our mouse populations, we will need to evaluate whether we desire to continue sampling mice.[1]

[1] Results of this testing showed a high incidence of antibodies to Hanta virus present in mice on San Miguel and Santa Rosa islands, but none on Santa Barbara Island. Middle and West Anacapa islets have been tested but results are not yet available.

With precautions taken for handler safety it could be done. However we would need to weigh the additional time and equipment required and risk to the investigators against the benefits of additional data. One compromise would be to continue sampling solely on Santa Barbara Island to maintain the long-term sampling which has been continuous for almost 15 years.

Island Fox *(Urocyon littoralis)* - San Miguel Island

INTRODUCTION

The island fox is a small canid which evolved from the larger gray fox *(Urocyon cinereoargenteus)* which occurs on the mainland (Wayne et al. 1991). The island fox is present only on the six largest of the eight California Channel Islands. Because of this restricted distribution and evidence suggesting limited genetic variability, the island fox was listed as a threatened species by the California Department of Fish and Game in 1971. This species is also extremely significant because of its status as the largest native mammal on the islands, and as one of only two native terrestrial predators (spotted skunks, *Spilogale gracilis amphiala,* are present on Santa Rosa and Santa Cruz islands). Island fox are commonly seen on the islands where they occur, and are found in almost all habitat types (Collins & Laughrin, 1979; Roemer et al. in press).

The prominence of the island fox in the terrestrial community, both ecologically and physically, has allowed this mid-size mammal to gain recognition by the non-scientific public that the gray fox has not earned on the mainland. To many people the island fox symbolizes the uniqueness of the islands, and it is pictured in almost all publications regarding the National Park and the Channel Islands.

While the appreciation of and concern for the status of the island fox is shared by scientists, island residents and the public alike, in some ways this recognition has and is restricting our ability to monitor this species. This animal is very 'cute' and petlike, and the initiation of the fox monitoring program this year attracted much attention and some protest. Most of the objections to the project were directed at the live trapping aspect of the work. The trap and release methods as described in the handbook were called everything from "animal cruelty" to unnecessary. As a result of these concerns an environmental assessment was conducted (NPS, 1993) to evaluate the effects of the island fox monitoring program on the environment, including effects on fox populations and individuals. During the development of the EA, we communicated with all the biologists we knew who had ever conducted research on island fox, and were reassured that the techniques we planned to use were humane and scientifically proven to provide sound data, with very little impact on fox behavior. It was also agreed by everyone we talked with that this was very important work, and the information needed to understand the ecology of this species could not be obtained by other methods.

Some of the concerns raised were reasonable and we modified the protocol accordingly. As a result of political pressures, as well as logistical considerations and a desire for improvement in the sampling design, by the beginning of the fox sampling period we had made several changes and one addition to the methods as described in the handbook. These alterations involved sampling dates, numbers of grids and grid size, and marking methods. Each of these changes is discussed in the Methods section below.

While being the most visible of our monitoring protocols, the fox program is also the most logistically complex. We spent much time preparing traps and equipment, experimenting with bait, and learning animal-handling and marking techniques. In these efforts we had a great deal of assistance from other fox researchers and local biologists. Without the availability of this knowledge and the desire of these people to help the project, this first year of fox monitoring would not have been as successful as we feel it was.

METHODS

The monitoring protocol for island fox calls for density and population estimate sampling using mark-recapture techniques (Fellers et al., 1988). Our methods followed the protocol closely, with some modifications in times of sampling, grid design and placement, and marking techniques (Appendix A).

The first change made to the written protocol involved when sampling would be conducted. In the protocol, the sampling period is set for the spring (February-April). This period was selected to prevent separation of pups from mothers by trapping before the pups are born in late April or early May (Fellers, pers. comm.). We chose to change the sampling period to late summer for three reasons. First, travel to and from the islands in the spring is often weather dependant. Since the fox trips require a great deal of logistical planning, we did not wish to have these trips cancelled once they were planned. Secondly, most of the sampling for other vertebrate taxa is scheduled for the spring and fall of the year (Fellers and Drost, 1988; this report). Again, due to the planning required for fox trips, we decided that it would be wiser to concentrate on these other protocols during the spring, leaving the summer available for fox work exclusively.

The most important consideration, however, was the reproductive season of the fox. Young fox do not leave the den until they are about four to six weeks of age, and are not usually weaned until about two months of age, when they begin foraging on their own (Laughrin, 1977; Collins & Laughrin, 1979; Fellers, pers. comm.). We therefore did not want to schedule any trapping until after weaning, which would be approximately July 1st. We did however desire to trap the pups while they still retained characteristics making them identifiable as young of the year. These pups grow quite quickly, and by September are almost indistinguishable from one or two year olds (Roemer, pers. comm.). For the above reasons, then, we placed our trapping season between July 15th and September 1st.

The second significant change made to the original protocol involved grid design, and included changes in grid size and spacing, and the number of grids trapped. After discussions with other researchers, including the authors of the handbook, it was decided that the grid should be enlarged and that traps should be placed closer together. This change was made primarily to mirror the methodology of other island fox studies. The trap spacing distance of 244 m had worked well in studies on San Clemente and Santa Catalina islands because increasing the number of traps in an animal's home range increases capture probabilities, (Brundige et al. 1990; Roemer pers. comm.). The trap distance as specified in the protocol, 322 m, was therefore reduced to 250 m. It was also determined that a larger grid would allow the capture of more animals and hence result in a more accurate estimate of density and population size. To stay within the limits of the habitats specified in the handbook using a trap spacing of 250 m, it was determined that a grid of seven by seven traps would work best. However, at the beginning of the study, we had only enough traps to establish a 6 x 7 grid at Willow Canyon. More traps had been purchased by the next trip, and the San Miguel Hill grid was run with 49 traps (Figure 4).

The second change made to the sampling design was a reduction in the number of grids we would trap per year. The monitoring design established five sampling grids in various habitat types on San Miguel island, three of which would be trapped every year, and two of which would be alternately trapped every other year. This meant that ideally four grids would be run every season. There was a concern expressed by some park employees that the trapping process affects long-term fox behavior. While there is no support for this idea from islands where long-term trapping has been conducted, (Collins, Garcelon, Kovach, Laughrin, Roemer, Smith, pers. comm.), we agreed that for the first few years we would trap a maximum of three grids each year. Whether the remaining two grids will be trapped on a less-frequent basis, on the order of every 3-5 years, or not at all, is yet to be determined. This first year, because of this controversy, we did not begin trapping until August, and hence only had time to trap two grids. The two grids chosed for this year were those closest to the ranger station, namely the Willow Canyon and the San Miguel Hill grids.

The final adjustment made to the protocol resulted from an expressed concern by the San Miguel Island Manager and a few other Park Service employees regarding the method of marking the fox with external ear tags. These tags are not large, but are only manufactured in bright colors, and are visible from a distance. Also, recaptured fox occasionally catch the tags on the sides of the trap, and tear or injure their ears. We agreed that we would like to eventually eliminate the use of these tags, if we could find a reliable alternative. With the support of park management, we initiated the experimental use of Passive Integrated Transponders (PIT) tags as a marking tool. These copper wires encased in glass are inserted under the skin of the animal and are read by means of a hand-held scanner. (See Schooley et al. 1993; Fagerstone & Johns, 1987 for further description). The tags contain no power source of their own, and so are theoretically useful for the life of the animal. Thus, each animal can be individually identified without the presence of external markers. In our study this year each animal trapped was marked with both an ear tag and a PIT tag to assess the reliability of the PIT tags.

A few additional smaller changes were made to the traps themselves, including the wiring of a plastic tube to the inside of the trap for the fox to chew on, again as a result of experience on other islands. The purpose of these modifications were to protect the fox from injury and stress as much as possible.

The vegetation and topography of the two grids is quite different. The first grid sampled, Willow Canyon (WC), is mostly a non-native annual grassland, with the northern 20 - 30% changing to thick shrubs of *Lupinus arboreus, Haplopappus venetus,* and *Coreopsis gigantea*. Several small tributary canyons to Willow Canyon run through this grid, mostly from southwest to northeast, and run into Willow Canyon, which runs northwest to southeast. Between the canyons the terrain is mostly flat, with the south end of the grid ending at the high cliffs which fall to the beaches on the south side. The San Miguel Hill (SMH) grid, directly west of the WC grid by 250 m, slopes upward on the north and south sides to the ridge which runs east to west through the center of the grid, and terminates at San Miguel Hill itself on the west side of the grid. Many medium to large size canyons run north to south on both sides of the ridge. The vegetation is quite heterogeneous, unlike the WC grid, which is either grassland or thick shrub but not usually both in the same area. The SMH grid contains many areas of bare ground and grasses on the south side, mixed with *Lupinus, Haplopappus, Baccharis pilularis,* and various herbaceous annuals and grasses. The north side of the ridge has few bare patches, and is mostly a mixture of woody shrubs and grassy areas. While this vegetation is easier to walk through than the high grass and thick shrubs of the WC grid, the canyons are deeper and tougher to negotiate.

Age designation of animals was based on tooth wear, with pups identified as those animals retaining cusps on the incisors, and age classes based on Nicholson & Hill, 1981. Data analysis was performed by the program CAPTURE, as described for the deer mouse monitoring protocol above.

RESULTS

Density and population estimates as well as juvenile/adult ratios from the two grids were quite similar (Table 7) . There were two more individuals trapped on the San Miguel Hill (SMH) grid than on the Willow Canyon (WC) grid, however this most likely reflects the larger grid size at SMH. There is a slight difference in the density estimates between the two grids, with more animals occurring per hectare on the SMH grid. Whether higher densities on the scrub lands of the SMH area are related to factors which create superior habitat here, or whether this observation is simply attributable to variations in trapping technique or data analysis or other peculiarities of the sampling design, the answers to these questions will be representative of the type of information which will be available only after several years of monitoring.

We were quite surprised and excited to catch several animals that had been trapped and collared many years ago during the design phase of the monitoring program. We have been fortunate enough to recover the data from this initial trapping (Table 8) (Fellers, pers. comm.). The observation of these collared animals has resulted in the first documentation of the ages of older fox, since all work in the past has estimated age outside the scope of the particular study by tooth wear. The age at the time of capture of the oldest fox we caught was at least nine years old, if they were at least one year old when first marked (Fellers, pers. comm.). Fellers also provided the locations where the collared animals were first caught. While not all of the historical trapping locations are available, we determined that there is one animal in particular that was recaptured by us only 300 meters from where she was first caught in 1985. Such habitat utilization and home range information is of great interest with respect to long-term movement of individuals around the island, and we look forward to recapturing some of these animals again next season.

Table 7. Results of island fox trapping on the Willow Canyon and San Miguel Hill grids in August, 1993

	WILLOW CANYON	SAN MIGUEL HILL
Nights of trapping	5	6
Individuals caught	40	42*
Total captures	58	70
Percentage of captures that were recaptures	31%	40%
Total adults	29	30
Total juveniles	11	12
Collared animals trapped	9	4
Estimated density	.13/ha (13/km^2)	.18/ha (18/km^2)
Mean maximum distance moved	350 m	375 m
Total population estimate for the grid (95% confidence interval)	43 (37-49)	46 (38-54)

* Six of these fox were first trapped and marked on the WC grid

Table 8. Calculated ages of foxes caught during the initial study phases and recaptured this year.

collar #	date first caught*	age in years	date first caught this study	calculated age this study
1050	10/05/85	1.5	8/04/93	8.5
1080	10/6/85	1.5	8/1/93	8.5
1110	11/6/88	2.5	8/4/93	7.5
1113	10/11/88	.5	8/5/93	5.5
1114	11/5/88	2.5+	8/2/93	7.5+
1116	10/9/88	2.5	8/22/93	7.5
1117	11/7/88	3.5	8/2/93	8.5
1118	1/9/89	2.5-3.5	8/1/93	7.5-8.5

* from G. Fellers, unpublished data

DISCUSSION

The first year of terrestrial vertebrate monitoring was successful in several ways. Data was collected as directed by the monitoring protocol, and although no observations can be made regarding populations' status or trends, what we observed and recorded this year will be a very good foundation on which to build the program. For the long-lived island fox, the presence of the permanent markers applied this year will continue to provide information on fox life history and population dynamics.

Without foreseeing the problems that would be encountered with logistics, transportation, and politics, we began the year assuming we could accomplish what was prescribed in the handbook. We found that we need to be prepared and ready to make changes to the written instructions, while maintaining the biology and the natural history of the organisms as the guides for modifications and improvements.

We also feel that the initiation of this program served to improve the image of the Park Service as an active member of the scientific community working on terrestrial vertebrate issues on the Channel Islands. While many scientists have conducted research on the islands over the years, until the initiation of this program, the park was relatively inactive regarding the study of its terrestrial vertebrates. In the course of the last year, we have initiated or reestablished communication with many well-known vertebrate scientists in the area. These relationships will contribute greatly to the long-term success of the program.

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